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INSTITUTE FOR DEFENSE ANALYSES

Evaluation Models for Standards and Products

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PREFACE

This document was prepared by the Institute for Defense Analyses (IDA) for the Information Technology Directorate, Office of Assistant Secretary of Defense (C3I), under the task entitled "TAFIM Standards Enforcement and the Market Place Influence." This document fulfills a task objective to provide a model and associated metrics for evaluating and measuring the capability of TAFIM standards and commercial products to meet the needs of an application.

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EXECUTIVE SUMMARY

Purpose

The purpose of this paper is to describe models and guidelines for assessing standards and standards-based, commercial off-the-shelf (COTS) products in the information technology field. The models are intended to be used to help choose among competing standards and standards-based COTS products. They can also be used to assess a single standard or product. The models and guidelines can be applied in a range of situations, from the selection of standards and products for a single specific system to the selection of recommended standards for a whole class of systems, as is done in the DoD Profile of Standards. There is a corresponding range of potential users, from system developers to program managers to technical architects.

Background and Scope

Standards, according to the International Organization for Standardization, are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose. Standards-based products are products that adhere to the technical specifications or criteria of one or more standards. Over the past decade and more, technology has driven the evolution of computer systems from large, stand-alone, proprietary systems based on a single powerful processor to decentralized, distributed systems composed of a variety of processors linked together via communications networks. This evolution has increased customers' demands that computer system components from different vendors be able to communicate and exchange information, which in turn has led to an increased appreciation of the value of standards. Currently, there are a large number of existing or emerging standards, some of which overlap or address the same technology areas. Users of standards need a method for evaluating and choosing among competing standards and standards-based products.

The standards and products evaluation models described herein are intended to provide the user with specific kinds of information about a standard or product. This informa-

tion may be useful in making certain types of decisions, specifically decisions regarding which standards or products of multiple ones might best serve identified needs or decisions regarding whether a given standard or product can serve those needs.

The information provided by these models cannot be applied blindly to select standards and products. They must be used in conjunction with human judgment within an overall decision-making process. The types of decisions that must be made before these models are applied include a decision as to where standards might be used within the system or domain along with an understanding of what benefits and costs will accrue as a result of using them — and a determination of which standards and COTS products address relevant, needed functionality. To use the results of the standards evaluation model or products evaluation model, a user must understand the needs of the system or domain under consideration, relative to the evaluation criteria of the models, and relate those needs to the strengths and weaknesses of the standards and products, as identified by the evaluation models. After the user has decided to adopt a particular standard or use a particular COTS product, based upon the evaluation results, the user should identify any risks associated with that choice and take action to reduce those risks. For a COTS product, such actions would include a viable (structured) demonstration of that product as well as testing that product against an objective set of tests.

The Evaluation Models

Standards and standards-based products are best chosen by considering the context in which they will be used. Relevant context includes the requirements of the system being acquired or developed, its architecture, and the pool of relevant standards and standards-based products from which choices can be made. A framework is presented for selecting standards and products that takes into account the context in which they will be used.

This document presents two models, one for evaluating standards and one for evaluating standards-based products. Each model presents a set of criteria, giving a brief description of each criterion and why that criterion is important. Related criteria are grouped into categories so that a standard or product can be evaluated by category instead of by individual criteria.

The standards evaluation model consists of 15 criteria grouped into four categories: quality, standards support, stability, and marketplace.

- Quality — The six criteria of completeness, technical quality, unambiguous expression, clarity, strictly-defined interface, and flexibility address the quality

of the standard. Poor quality standards can limit the degree of interoperability and portability of products based on them.

- Standards support — The support for a standard is measured by the credentials of the standard's approving body, by the standard's scope of acceptance, and by the standard's conformance specification.
- Stability — The stability of domain, lifecycle of standard, and stability of standard all give some indication of how mature a standard is and how long it is likely to remain influential. A stable standard is desirable because change in a standard can be expensive to those who have adopted it.
- Marketplace — Marketplace considerations can determine how long a standard will be influential. They also determine the amount of choice there will be in selecting a product to conform to the standard. There are three criteria in the marketplace category: number of acceptable products, marketplace presence, and cost of standard.

The standards products evaluation model consists of 21 criteria grouped into seven categories: quality, integration with other products, standards support, product support, manageability, stability, and marketplace.

- Quality — The quality category addresses a product's performance, reliability, robustness, functionality, and ease of use.
- Integration — Interoperability, portability, and scalability focus on the ease with which a product can be integrated with other products and into other environments.
- Standards support — The two criteria in this category address the product's conformance to the standard(s) on which it is based: conformance accreditation and degree of conformance. They are applicable only to products that are based on standards.
- Product support — The product warranty and service support criteria address how much support a purchaser is likely to get from a vendor if problems occur in using the product.
- Manageability — This deals with the practical concerns in bringing a product into an organization, setting it up, and maintaining it for use. These criteria are:

ease of installation and integration, training and professional support, license management, and remote management.

- Stability — Vendor stability addresses the likelihood that the vendor will remain in business to support the product. Product maturity addresses the robustness of a product and how likely and how often it needs to be upgraded.
- Marketplace — Marketplace considerations can determine how long a product will be supported by its vendor and how costly it will be to use. These criteria are: marketplace presence, third-party support, and cost of product.

The models are flexible and can be tailored to a given situation. Certain criteria can be emphasized or de-emphasized, according to situational needs. Further, the models themselves can easily be extended or modified based on experience in their use. Criteria can be added or deleted and assessment guidelines further developed. As the models are more widely used, they can evolve to become more precise instruments for evaluating standards and products.

1. INTRODUCTION

1.1 PURPOSE

The purpose of this paper is to describe models and guidelines for assessing standards and standards-based, commercial off-the-shelf (COTS) products in the information technology field. The models are intended to be used to help choose among competing standards and standards-based COTS products. They can also be used to assess a single standard or product. The models and guidelines can be applied in a range of situations, from the selection of standards and products for a single specific system to the selection of recommended standards for a whole class of systems, as is done in the DoD Profile of Standards [DOD 93b]. There is a corresponding range of potential users, from system developers to program managers to technical architects.

1.2 BACKGROUND

Standards, according to the International Organization for Standardization, are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose. Standards-based products are products that adhere to the technical specifications or criteria of one or more standards. Over the past decade and more, technology has driven the evolution of computer systems from large, stand-alone, proprietary systems based on a single powerful processor to decentralized, distributed systems composed of a variety of processors linked together via communications networks. This evolution has increased customers' demands that computer system components from different vendors be able to communicate and exchange information, which in turn has led to an increased appreciation of the value of standards. Currently, there are a large number of existing or emerging standards, some of which overlap or address the same technology areas. Users of standards need a method for evaluating and choosing among competing standards and standards-based products.

1.3 SCOPE

The standards and products evaluation models described here are intended to provide the user with specific kinds of information about a standard or product. This information may be useful in making certain types of decisions, specifically decisions regarding which of multiple standards or products might best serve identified needs or decisions regarding whether a given standard or product can serve those needs.

The information provided by these models cannot be applied blindly to select standards and products. They must be used in conjunction with human judgement, within an overall decision-making process. The types of decisions that must be made before these models are applied include a decision as to where standards might be used within the system or domain along with an understanding of what benefits and costs will accrue as a result of using them; and a determination of which standards and COTS products address relevant, needed functionality. In order to use the results of the standards evaluation model or products evaluation model, a user must understand the needs of the system or domain under consideration, relative to the evaluation criteria of the models, and relate those needs to the strengths and weaknesses of the standards and products, as identified by the evaluation models. After a decision has been made to adopt a particular standard or use a particular COTS product, the user should identify any risks associated with that choice, as illuminated by the evaluation results, and take actions to mitigate those risks.

1.4 APPROACH

While it would have been desirable to create a rigorously predictive quantitative model for evaluating standards, our investigation has concluded that existing knowledge is not adequate to create such a model. Instead, the approach taken has been to develop a more subjective model and guidelines that provide direction in understanding how to evaluate standards and products, a checklist to insure that every important aspect has been investigated, and a codification of knowledge about the desirability of different aspects of standards and products.

In order to form a basis for the model, several people, both within and outside of IDA, participated in discussions concerning the characteristics of a good standard. All of the people interviewed had extensive experience in the standards area, many having participated on standards development committees. The information from these interviews was used to create preliminary sets of evaluation criteria for standards and standards-based products. These criteria were refined over the course of reviews by other standards-knowledgeable professionals. The standards evaluation model was further elaborated by creating assessment guidelines for each

of its criteria. The model was then used to evaluate ten standards, most of which were taken from the profile of standards associated with the DoD Technical Reference Model. As a result of that evaluation exercise, further modifications were made to the model.

The form of the standards evaluation model presented here is very similar to that of the model developed by the National Institute of Standards and Technology (NIST) as part of its Application Portability Profile [NIST 95]. Both models contain a set of evaluation criteria and guidelines for assessing a standard relative to the criteria. The major differences are in the number of evaluation criteria (7 for NIST, 15 for the standards evaluation model), the number of assessment levels for each criterion (3 for NIST, 5 for the standards evaluation model), and the amount of guidance given to the user in assessing a standard.

1.5 ORGANIZATION OF THE DOCUMENT

Standards and standards-based products are best chosen by considering the context in which they will be used. Relevant context includes the requirements of the system being acquired or developed, its architecture, and the pool of relevant standards and standards-based products from which choices can be made. Chapter 2 presents a framework for selecting standards and products that takes into account the context in which they will be used.

Two models are presented in Chapter 3, one for evaluating standards and one for evaluating standards-based products. The models present a set of criteria that can be used in evaluating standards and products. They give a brief description of each criterion that may include reasons why the criterion is important. The models are meant to be used in conjunction with the selection framework presented in Chapter 2.

Chapter 4 develops the standards evaluation model further by presenting guidelines for assessing each of its criteria. It also offers guidelines for using and tailoring the evaluation model. Chapter 5 provides a summary of the document.

2. SELECTION FRAMEWORK

Standards and standards-based products should not be chosen in a vacuum. The requirements and architecture of the system being built are important sources of contextual information that should guide their selection. This chapter presents a four-tiered framework, depicted in Figure 2-1, that can be used to guide the selection of standards and standards-based products.

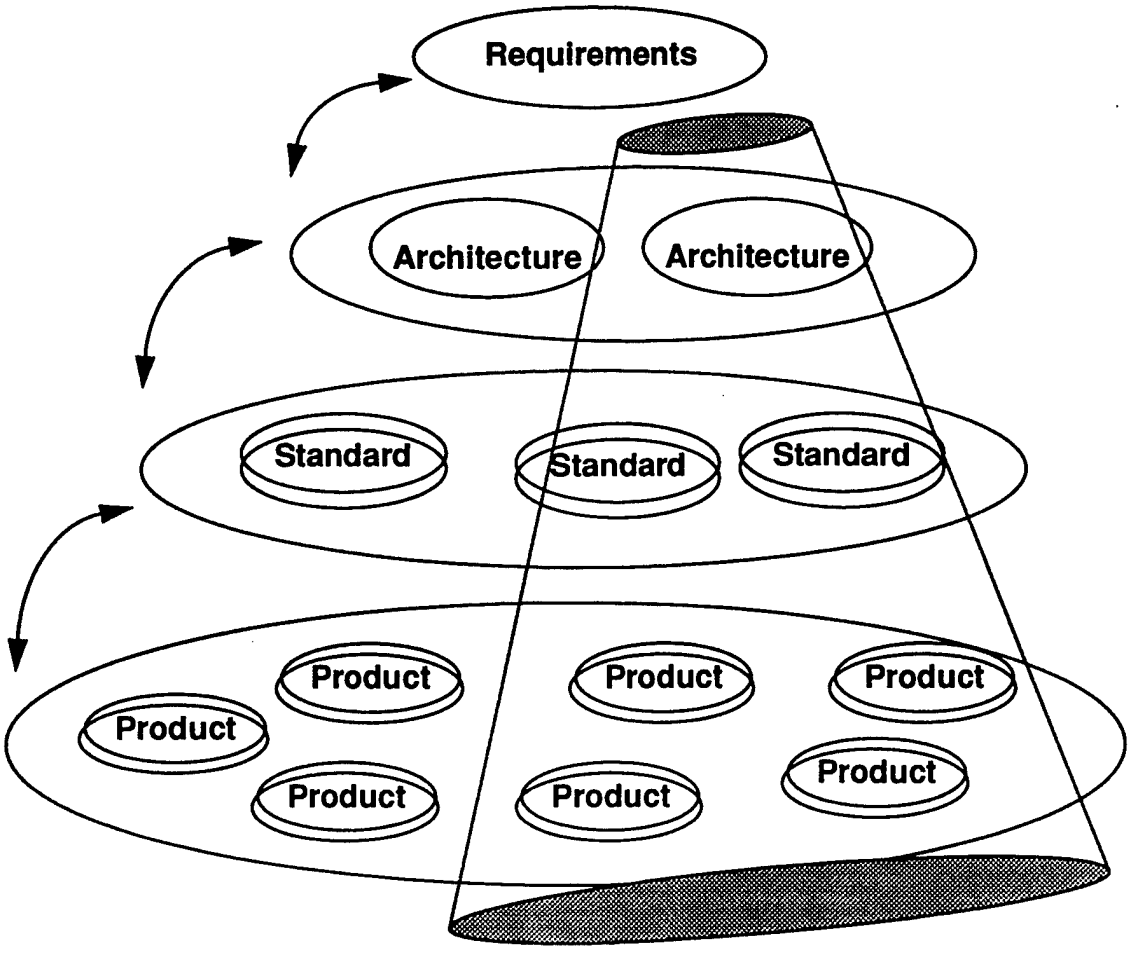

Figure 2-1. Selection Framework

Ideally, the requirements established at the higher tiers should determine the choices available at the lower tiers. However, as the double-headed arrows are intended to indicate, lower tiers may also impact choices at higher tiers. For example, the availability of an outstanding product may influence the choice of a standard. Even the highest tier, requirements, is not immune to change resulting from decisions made at a lower level. For example, in many large systems such as the Global Command and Control System (GCCS) and the Defense Information Infrastructure (DII), architecture is dictating to some extent which requirements will be accommodated.

Each of the four tiers, Requirements, Architecture, Standards, and standards-based Products, is described in this chapter. The final section of the chapter discusses a process for selecting standards and products using the selection framework, the evaluation models presented in Chapter 3, and the assessment guidelines presented in Chapter 4. The selection process can be used in different contexts, including the development of a software product, the creation of a software system composed of commercial off-the-shelf (COTS) and developed products, and the development of guidance (e.g., in the form of a technical architecture) for creating software systems.

2.1 REQUIREMENTS

The top tier of the selection framework is requirements. Requirements for a system include functional requirements, non-functional requirements, and external requirements or constraints. Functional requirements describe what the system does in terms of the inputs and outputs of the system and how they interrelate.

Non-functional requirements delineate non-functional aspects of a system such as performance, reliability, portability, cost, etc. Some of the non-functional requirements such as portability may express the needs of the organization acquiring the system, while others such as performance more directly express the needs of the user. Non-functional requirements commonly address areas such as the following:

1. Portability
2. Scalability
3. Interoperability
4. Flexibility
5. Cost

6. Performance
7. Robustness
8. Reliability
9. Availability
10. Security
11. Maintainability

Many non-functional requirements can be achieved without the use of standards. However, requirements in the areas of portability and interoperability typically require that standards be used.

External requirements or constraints are those imposed by other systems or by a parent organization. A common example is the requirement to be compatible with existing artifacts such as databases or applications in use within the organization. Other examples are the policy, legal, and environmental requirements established by the DoD and imposed on all organizations within its purview.

2.2 ARCHITECTURE

Architecture is defined as the organizational structure of a system or component [IEEE 610.12]. Various views of architecture exist in the open systems arena. The DoD currently is working towards a definition of three types of architecture: operational, systems, and technical. The following represent DoD's proposed definitions of the three types of architecture:

1. Operational Architecture covers the descriptions of the tasks, operational elements, and information flows required to accomplish or support a warfighting function.
2. Systems Architecture covers the descriptions, including graphics, of systems and interconnections providing for or supporting warfighting functions.
3. Technical Architecture covers a minimal set of rules governing the arrangement, interaction, and interdependence of the parts or elements whose purpose is to ensure that a conformant system satisfies a specified set of requirements.

The architecture component of the selection framework can represent different ones of these architectures, depending on the context in which the framework is used. For example, if used in the context of a systems development, it represents a systems architecture, describing

both the components of the system under development as well as all external interfaces of the system to other, existing systems. If used in the context of developing guidance for a whole domain of systems, it represents a technical architecture.

2.3 STANDARDS

There are a large number of standards in existence today. It is estimated, for example, that there are approximately 35,000 US military specifications and standards. Even in the restricted arena of information technology, there are hundreds if not thousands of different standards from which to choose.

Many standards are broad in coverage. They may define ranges of values rather than single values and provide options for adhering to the standard. Product implementors must decide which options to implement. Users must decide which options are suited to their needs.

The problem is compounded when multiple broad standards must be chosen to operate together. In order to facilitate the selection of related, complex standards, profiles are developed. A profile is a set of one or more base standards, and, where applicable, the identification of chosen classes, subsets, options and parameters of those base standards, necessary for accomplishing a particular function [ISO/IEC 95]. Profiles constrain a user's choice of standards and hence aid in standards selection. One of the most visible profiles today is NIST's Application Portability Profile [NIST 95], which is intended to direct users in their selection of information technology standards to create a computing environment that supports portability. Another widely-regarded profile is the DoD Profile of Standards [DOD 93b], which identifies standards relevant to the information system services identified in the Technical Reference Model (TRM) of the TAFIM [DOD 93a].

2.4 STANDARDS-BASED PRODUCTS

Some standards have many products that are based on them, while other standards may have none. The availability of products that conform to a standard can be an important consideration in the selection of a standard. Likewise, one of the significant issues in selecting a standards-based product is the quality of the standard on which it is based. The selection of a standard and a standards-based product are often interlinked.

2.5 PROCESS FOR SELECTING STANDARDS AND PRODUCTS

Very often, standards are selected implicitly and without thought, as a consequence of the choice of a familiar or recommended product. While circumstances may sometimes dictate

that decisions be made in a bottom-up order, the choices made at every level of the selection framework should be made explicitly and after consideration of the alternatives and the consequences.

Ideally, the functional, non-functional, and external requirements should drive every decision that is made in implementing the system, from the development and selection of an architecture for the system to the selection of standards and standards-based products that will be incorporated into the system. After all, without the necessity for satisfying the functional requirements, there would be no point in developing the system at all. Elaborating the ideal situation further, once a system architecture based on requirements is developed, it, along with the requirements, should drive the selection of standards; and once standards are chosen, they will dictate the pool of products from which a final choice must be made.

Often, marketplace and other realities will prescribe a different order of decision making. It might be that the choice of the "best" system architecture, based solely on the system requirements, would dictate the choice of an immature standard or of a standard that has inadequate product support, while the choice of the second best system architecture would permit the selection of a mature standard supported by several excellent products.

Therefore, a strict top-down decision-making process, where system architecture is developed based solely on requirements, standards are selected based on system architecture and requirements, and products are chosen always after standards are selected, cannot be recommended in all situations. What is recommended instead is a process that at each decision level of the selection framework (system architecture, standards, and products) looks up to ensure that all requirements from the levels above are met and looks down to assess the consequences of a decision on the levels below. Judgment must then be applied in making the decision. This is an engineering process that attempts to make the best *set* of decisions so as to maximize the benefits on the eventual developed system and the environment in which it is used.

The role of the requirements and architecture in the decision-making process for selecting standards is summarized in Table 2-1. The need for using standards may be dictated by the non-functional requirements of portability, scalability, and interoperability, which typically can only be satisfied through the use of standards. External requirements such as an adopted technical architecture may also dictate the use of standards. The set of relevant standards will be defined by the functional requirements, external requirements, and system architecture, and may be constrained by external requirements. Finally, the criteria that should be most significant in assessing a standard will be determined by non-functional and external requirements.

Table 2-1. Roles of Requirements and Architecture in Selecting Standards

Requirements/Architecture	Role
Functional Requirements	Determine set of functionally relevant standards
Non-functional Requirements	Create need for standards Determine most relevant standards evaluation criteria
External Requirements	Create need for standards Constrain set of standards Determine most relevant standards evaluation criteria
System Architecture	Determine set of architecturally relevant standards

Once a set of relevant standards has been determined, the standards evaluation criteria (Chapter 3) and assessment guidelines (Chapter 4) can be used to evaluate the competing standards. The results of the evaluation can then be used to help determine which standard best meets the needs of the organization, as well as to identify any risks associated with adopting that standard.

Often, a set of standards must be chosen with the requirement that each individual standard integrate well with the other standards in the set. In a case like this, the selection process can be broken into two phases. In the first phase, an evaluation is done of how well individual standards integrate with each other. In the second phase, evaluations of the individual standards can be done using the standards evaluation model. Information from both phases can then be used to choose the best set of integrating standards.

3. EVALUATION MODELS

This chapter presents an evaluation model for standards and an evaluation model for standards-based products. The two models are similar. Each consists of a set of criteria that can be used to assess a standard or a standards-based product. Related criteria are grouped into categories, so that a standard or product can be evaluated by category instead of by individual criteria. Table 3-1 shows the standards evaluation model, which consists of fifteen criteria grouped into four categories, and the products evaluation model, which consists of twenty-one criteria grouped into seven categories. The lists of criteria have been developed based on the expertise of several professionals knowledgeable in the area of information technology standards. However, the lists are not exhaustive, and other experienced professionals may have a different opinion as to which evaluation criteria are most important.

It is assumed that the standards and products being evaluated are relevant to the system or domain under consideration. There is no criterion that evaluates the extent to which a standard or product addresses the needed functionality. By leaving a *functionality* criterion out of the model, it has in effect been given the highest possible weight. Standards or products that are not functionally relevant are not considered further, no matter what other strengths they may possess.

The remainder of this chapter will give a brief description of each of the evaluation criteria for standards and standards-based products..

Table 3-1. Evaluation Models for Standards and Standards-based Products

Evaluation Categories	Standards Evaluation Criteria	Products Evaluation Criteria
Quality	Completeness Technical Quality Unambiguous Expression Clarity Strictly-defined Interface Flexibility	Performance Reliability Robustness Functionality Ease of Use
Integration with Other Products		Interoperability Portability Scalability
Standards Support	Credentials of Approving Body Scope of Acceptance Conformance Specification	Conformance Accreditation Degree of Conformance
Product Support		Product Warranty Service Support
Manage-ability		Ease of Installation & Integration Training and Professional Support License Management Remote Management
Stability	Stability of Domain Lifecycle of Standard Stability of Standard	Vendor Stability Product Maturity
Marketplace	Number of Acceptable Products Marketplace Presence Cost of Standard	Marketplace Presence Third-party Support Cost of Product

3.1 EVALUATION CRITERIA FOR STANDARDS

The fifteen evaluation criteria for standards are grouped into four categories: quality, standards support, stability, and marketplace.

3.1.1 Quality

The six criteria of completeness, technical quality, unambiguous expression, clarity, strictly-defined interface, and flexibility address the quality of the standard. Poor quality standards can limit the degree of interoperability and portability of products based on them.

The quality criteria are not independent of each other. Some of them interrelate to produce desirable results. For example, the criteria of completeness, unambiguous expression, and strictly-defined interface work together to produce a standard whose conforming products are more likely to be able to interoperate. Others of the quality criteria almost oppose each other, so that it may not be possible for a standard to score highly on each of them. For example, to achieve flexibility in a standard may require that areas of the standard deliberately be left incomplete, so as to allow for future developments.

Completeness

A standard is complete if it addresses all functionality that is relevant and necessary to the domain and scope of the standard and if each area of functionality is fully covered. If a standard is incomplete, product implementers are free to define how the unaddressed functionality will be provided. This will have a negative impact on interoperability.

Technical Quality

Technical quality refers to the quality of the concept(s), model(s), and/or technology that are central to the standard. It addresses such issues as whether they are simple rather than complex, are likely to yield good performance, or have significant limitations.

Unambiguous Expression

A standard is unambiguous if each of its requirements is precisely expressed and is not open to interpretation. Further, the requirements as a group must be self-consistent, so that each can be conformed to without impacting conformance to any other. An ambiguous standard is detrimental to interoperability.

Clarity

Clarity refers to the ease with which the written standard can be comprehended, assuming competence in any technologies underlying the standard.

Strictly-defined Interface

A standard has a strictly-defined interface if it does not provide multiple ways for an implementer to deliver a single function, and does not permit variations in the interface for a single function.

Flexibility

A standard is flexible if it makes some allowance for future developments. One example of a flexibility mechanism is a self-defining data format that permits data-interchange standards to handle unanticipated types of data. Flexibility mechanisms help keep a standard from becoming outdated when new features appear.

3.1.2 Standards Support

The support for a standard is measured by the credentials of the standard's approving body, by the standard's scope of acceptance, and by the standard's conformance specification.

Credentials of Approving Body

Credential of approving body encompasses both the sphere of influence of the bodies that either develop or endorse the standard, and their expertise in developing standards.

Scope of Acceptance

Scope of acceptance addresses the breadth of the community that uses a standard.

Conformance Specification

Conformance specification deals with how well the conformance requirements are defined (e.g., specification of levels of conformance, implementation options, test suites) and how well they are supported.

3.1.3 Stability

The three criteria in the stability category (stability of domain, lifecycle of standard, and stability of standard) give some indication of how mature a standard is and how long it is likely to remain influential. A stable standard is desirable because change in a standard can be expensive to those who have adopted it.

Stability of Domain

Stability of domain measures the stability of the hardware and software technology in the domain of the standard, which will impact the stability of the standard itself. A stable domain implies that a standard will be meaningful for a longer period of time.

Lifecycle of Standard

This criterion gives some indication of where a standard is in its lifecycle. Is it still in draft form, or has it been accepted and approved? Is it still in its prime or is it starting to be displaced by competing standards?

Stability of Standard

The stability of a standard refers to the frequency with which it is being augmented or changed; when the expected next changes are to occur; the pattern of changes; and whether older versions of the standard have remained compatible with newer versions.

3.1.4 Marketplace

Marketplace considerations can determine how long a standard will be influential. They also determine the amount of choice there will be in selecting a product to conform to the standard. There are three criteria in the marketplace category: number of acceptable products, marketplace presence, and cost of standard.

Number of Acceptable Products

This criterion indicates the amount of choice available in selecting a product to support the standard.

Marketplace Presence

Marketplace presence refers to the percentage of the marketplace covered by all products adhering to the standard, relative to the total market covered by all products of all competing standards.

Cost of Standard

Cost of standard refers to the cost of complying with the standard and covers whatever costs are perceived by the user.

3.2 EVALUATION CRITERIA FOR STANDARDS-BASED PRODUCTS

The twenty-one evaluation criteria for standards-based COTS products have been organized into seven categories: quality, integration with other products, standards support, product support, manageability, stability, and marketplace. Many of these evaluation criteria are applicable to products that have not been based on standards as well as to those that have been based on standards.

3.2.1 Quality

The quality category addresses a product's performance, reliability, robustness, functionality, and ease of use.

Performance

Most products have performance requirements placed upon them. Performance requirements usually address speed, but may also address throughput, capacity, etc. There are several ways that speed requirements can be expressed, e.g., average speed, worst-case speed, etc. Depending on the situation, a product may have to be evaluated for several different performance criteria.

Reliability

The reliability of a product refers to the dependability with which it operates correctly. Reliability is often measured as the mean time between failures.

Robustness

Robustness measures a product's response to unanticipated or incorrect inputs. Can it continue operating? Does it shut down gracefully, without losing critical data?

Functionality

The functionality of a product is measured by the extent to which it satisfies identified user needs. This criterion is related to the product maturity criterion, in that it is likely that more mature products will have more functionality.

Ease of Use

This category measures how easy a product is to use, whether by a novice or experienced user.

3.2.2 Integration with Other Products and with Environment

The criteria under the integration category focus on the ease with which a product can be integrated with other products and into other environments.

Interoperability

Interoperability is defined as the ability of two or more systems or components to exchange and use information [IEEE 610.12]. Interoperability, thus, is not a property of a single product, but rather a property of two or more products relative to each other. To the extent that a product uses standard communication protocols, data interchange formats, and distributed system interfaces to send, receive, and use information, it will be more likely to interoperate with other products.

Portability

Portability is the ease with which a system or component can be transferred from one hardware or software environment to another [IEEE 610.12]. The portability of a product can be enhanced by developing it using a standardized programming language and standardized interfaces to its computing environment.

Scalability

Scalability refers to the ability to use application software on many different classes of hardware/software platforms from personal computers to super computers.

3.2.3 Standards Support

The two criteria in this category address the product's conformance to the standard(s) on which it is based. They are applicable only to products that are based on standards.

Conformance Accreditation

This criterion evaluates the strength of any claims made concerning the product's conformance to standards. For example, claims made by the vendor but not supported by any testing would be considered weak claims. At the other extreme, conformance claims based on the execution of an accepted conformance test suite by a third-party testing organization (i.e., an organization independent of the vendor and the purchaser) would be considered very strong.

Degree of Conformance

This criterion measures how much of a standard the product conforms to, and to what depth it conforms. It also addresses a product's known extensions to a standard, since they may affect a product's portability.

3.2.4 Product Support

The criteria in this category address how much support a purchaser is likely to get from a vendor if problems occur in using the product.

Product Warranty

Hardware products often come with a warranty that the product will work correctly for some period of time. Software will assuredly come with a trivial warranty that protects the purchaser if the software has been corrupted on the distribution media. However, stronger warranties should be available to assure that the software will operate correctly in the purchaser's environment.

Service Support

This criterion measures the extent to which the user is supported if he or she has difficulties with the product. Is there phone-line support, on-site support, bulletin-board support? Is a collection of common problems and solutions available for customers to peruse? Are bug fixes conveniently available? How far does the vendor go to make sure that customers are satisfied?

3.2.5 Manageability

The manageability criteria deal with the practical concerns in bringing a product into an organization, setting it up, and maintaining it for use.

Ease of Installation and Integration

This criterion measure the ease with which a product can be installed and then integrated into an existing hardware/software environment.

Training and Professional Support

This criterion measures the amount of training needed for end users, support personnel, and system administrators to be able to deal with and use the product, the availability of training, and the amount of on-going professional support required for optimum use of the product.

For some products, the end user needs no support; for others, perhaps only occasional support is needed; while for still others a fairly constant access to technical support staff may be required.

License Management

License management measures how difficult it is to manage the licensing for the product, whether there be one license for each user, a token-based licensing scheme, or an unlimited group license.

Remote Management

This criterion measures the ease with which a product can be managed from a central site. It is most important for large organizations that want to centralize the management of products used throughout the organization.

Training Requirements

This criterion measures the amount of training needed and available for end users, support personnel, and system administrators to be able to deal with and use the product.

3.2.6 Stability

The stability criteria deal with the maturity of a product and the stability of its vendor.

Vendor Stability

Vendor stability measures the likelihood that the vendor will remain in business. This is important if upgrades to the product are desired or if support for the product is needed for a significant period of time.

Product Maturity

Product maturity is a measure of how likely a product is to be upgraded with new features. It is also a measure of how error-free the product is. Maturity is often but not always related to the age of a product, because over time more features are typically added and hopefully, more problems are removed.

3.2.7 Marketplace

Marketplace considerations can determine how long a product will be supported by its vendor and how costly it will be to use. There are three criteria in the marketplace category: marketplace presence, third-party support, and cost of product.

Marketplace Presence

This criterion measures the percentage of the market captured by the product, relative to the total market shared by all competing products that support the same standard(s). A product with more market share is likely to be supported for a longer period of time.

Third-party Support

This criterion measures the amount of third-party support available for a product, including training, technical support, and value-added capabilities.

Cost of Product

Cost of product refers to whatever costs are perceived by the user as part of the cost of using the product. It might include items such as the initial purchase price, upgrade costs, and support costs, as well as costs associated with training and technical support for the product.

4. GUIDELINES FOR ASSESSING A STANDARD RELATIVE TO THE EVALUATION CRITERIA

The first part of this chapter will give guidelines for assessing a standard relative to the evaluation criteria in the standards evaluation model. Assessments will be made on a five-point scale, with 1 representing the lowest score and 5 the highest. These rating levels are meant to correspond to a grading of poor, fair, average, good, and excellent, respectively. The guidelines for level 5 will be presented first, then those for level 4, and so forth. The first level that accurately describes the standard represents the assessment of the standard relative to that criterion. Some criteria may not use all five assessment levels. For example, the flexibility criterion uses only three of the five assessment levels, excellent, average, and poor.

The assessment guidelines for the standards evaluation criteria are phrased using objective terms wherever possible. Some guidelines however use subjective terms and require judgment to be applied. Further, the judgment can be based on a great deal or very little research into the standard and technologies in question. The guidelines cannot make the evaluation a rote activity. What they can do is guide the reviewer toward making assessments in a consistent way, considering the same qualifications for each standard that is evaluated.

As much as possible, the assessment guidelines are stated in such a way as to allow a standard to be assessed in absolute terms rather than assessed relative to another standard or relative to a particular situation. The major advantage of this approach is that a single evaluation of a standard can be used by many different organizations and can be compared against the evaluation of any other related standard. The one criterion that has been expressed in relative terms is the cost criterion.

The evaluation model and assessment guidelines can be used to compare two or more standards. They can also be used to compare a single standard against the requirements of a given organization for a given system. Both the standard and the organizational needs could be assessed relative to the standards evaluation model. A judgement could then be made of how well the standard meets the organizational needs.

Assessments can be compared at the level of the fifteen individual criteria. Alternatively, evaluations of the criteria within categories can be combined for overall category assessments which can then be compared. The results of the assessments can be displayed in a tabular format, in a line graph or Kiviat diagram, in bar charts, or in any other desired way.

While several additional significant criteria could be added to the standards evaluation model, it is likely that the present fifteen criteria may be too numerous to allow for a practical and focused evaluation. Section 4.2 gives some guidelines for tailoring the use of the evaluation model to reflect the most important needs of the organization. Section 4.3 illustrates the use of the assessment guidelines with an example standard evaluation.

4.1 ASSESSMENT GUIDELINES

4.1.1 Quality

Completeness

A standard is complete if it addresses all functionality that is relevant and necessary to the domain and scope of the standard and if each area of functionality is fully covered. If a standard is incomplete, product implementers are free to define how the unaddressed functionality will be provided. This will have a negative impact on interoperability.

In the guidelines for evaluating completeness, the word 'major' refers to functionality that is central to the domain of the standard, while 'minor' refers to functionality that, while important, is more on the periphery and may not be needed in all circumstances. A particular area of functionality is fully covered if every significant aspect of it is addressed.

5. All relevant areas of functionality, major and minor, are addressed and fully covered.
4. Only one minor area of functionality is not addressed or is not fully covered. All major areas of functionality are addressed and fully covered.
3. At most two major areas and two minor areas of functionality are not addressed or are not fully covered.
2. At most two major areas and two minor areas of functionality are not addressed.
1. More than two major areas of functionality are not addressed.

Technical Quality

Technical quality refers to the quality of the concept(s), model(s), and/or technology that are central to the standard. It addresses such issues as whether they are simple rather than complex, are likely to yield good performance, or have significant limitations.

5. Central concepts, models, and/or technology of the standard are well-suited to their purpose and are well-understood (e.g., reference models or formal models are available). They are elegant and simple, provide excellent performance in areas relevant to the domain (e.g., speed, reliability), and have no known limitations relevant to the domain of the standard.

4. Central concepts, models, and/or technology of the standard are well-suited to their purpose and are well-understood. They have few areas of complexity, provide good performance in areas relevant to the domain (e.g., speed, reliability), and have at most a few minor limitations relevant to the domain of the standard.

3. Central concepts, models, and/or technology of the standard are suited to their purpose. They are more simple than complex, provide acceptable performance in areas relevant to the domain (e.g., speed, reliability), and have minor limitations and /or at most one major limitation relevant to the domain of the standard.

2. Central concepts, models, and/or technology of the standard are somewhat suited to their purpose. They may not be completely understood or proven. They have significant areas of complexity, provide minimally acceptable performance in areas relevant to the domain (e.g., speed, reliability), and have two or more major limitations relevant to the domain of the standard.

1. Central concepts, models, and/or technology of the standard are not well-suited to their purpose. They have significant areas of complexity, provide unacceptable performance in at least one area relevant to the domain (e.g., speed, reliability), and have two or more major limitations relevant to the domain of the standard.

Unambiguous Expression

A standard is unambiguous if each of its requirements is precisely expressed and is not open to interpretation. Further, the requirements as a group must be self-consistent, so that each can be conformed to without impacting conformance to any other. An ambiguous standard is detrimental to interoperability.

5. The standard states all requirements explicitly, using precise language and providing objective criteria which must be satisfied in order to conform to the standard. Each requirement is consistent with all of the others.

4. The standard states all requirements explicitly, but in a few minor cases language may be imprecise or objective criteria for satisfying the standard may be missing. Each requirement is consistent with all of the others.

3. A few minor requirements are implicit or are stated using imprecise language and giving either subjective criteria or no criteria for satisfying the standard. Each requirement is consistent with all of the others.

2. One or two significant requirements are implicit or are stated using imprecise language and giving either subjective criteria or no criteria for satisfying the standard. There are at most two inconsistencies among the requirements of the standard.

1. Several significant requirements are implicit or are stated using imprecise language and giving either subjective criteria or no criteria for satisfying the standard. There may be more than two inconsistencies among the requirements of the standard.

Clarity

Clarity refers to the ease with which the written standard can be comprehended, assuming competence in any technologies underlying the standard.

5. It is easy to read and understand the individual sentences of the standard, and easy to understand all major and minor requirements of the standard. A description of the rationale for the standard and the contexts in which it is intended to be used, as well as the definition of significant terms are included as part of the standard.

4. It is easy to read and understand the individual sentences of the standard, and easy to gain an understanding of all major and minor requirements of the standard.

3. It is difficult to read and understand some of the individual sentences of the standard, and/or requires some effort to gain an understanding of the major and minor requirements of the standard.

2. It is difficult to read and understand some of the individual sentences of the standard, and/or requires significant effort to gain an understanding of the major requirements of the standard.

1. It is difficult to read and understand many of the individual sentences of the standard, and/or requires significant effort to gain even a partial understanding of the major requirements of the standard.

Strictly-defined Interface

A standard has a strictly-defined interface if it does not provide multiple ways for an implementer to deliver a single function, and does not permit variations in the interface for a single function.

5. All aspects of the interface are specifically and concretely defined, giving no options to the implementer.
4. One or two functions in the interface allow a range of permissible parameter values rather than a single permissible value. All other aspects of the interface are specifically and concretely defined, giving no options to the implementer.
3. Several functions in the interface allow a range of permissible parameter values rather than a single permissible value. All other aspects of the interface are specifically and concretely defined, giving no options to the implementer.
2. One or two functions in the interface can be provided in more than one way. All other aspects of the interface are specifically and concretely defined, giving no options to the implementer.
1. Several functions in the interface can be provided in more than one way.

Flexibility

A standard is flexible if it makes some allowance for future developments. One example of a flexibility mechanism is a self-defining data format that permits data-interchange standards to handle unanticipated types of data. Flexibility mechanisms help keep a standard from becoming outdated when new features appear.

5. Multiple flexibility mechanisms, allowing for future and unforeseen developments, have been defined as part of the interface of the standard.
3. A single flexibility mechanism, allowing for future and unforeseen developments, has been defined as part of the interface of the standard.
1. No flexibility mechanism, allowing for future and unforeseen developments, has been defined as part of the interface of the standard.

4.1.2 Support

Credentials of Approving Body

Credential of approving body encompasses both the sphere of influence of the bodies that either develop or endorse the standard, and their expertise in developing standards. The term "standard" is used loosely to include specifications that have been produced outside of a standards organization, as well as specifications that are represented by products rather than documents.

5. The standard has been developed or endorsed by an international standards organization or U.S. national standards organization.
4. The standard has been developed or endorsed by a consortium, forum, or special interest group.
3. The standard has been developed or endorsed by the U.S. Department of Defense.
2. The standard is a de facto or company-proprietary standard.
1. All other standards, including those developed by a local organization for internal use.

Scope of Acceptance

Scope of acceptance addresses the breadth of the community that uses a standard. The term "standard" is used loosely to include specifications that have been produced outside of a standards organization, as well as specifications that are represented by products rather than documents.

5. The standard is accepted by a community that is international and that spans the domain(s) in which the standard is applicable.
4. The standard is accepted by a U.S. national community that spans the domain(s) in which the standard is applicable.
3. The standard is accepted internationally or throughout the U.S. by a community that spans a significant segment of the domain(s) in which it is applicable.
2. The standard is accepted regionally by a community that spans the domain(s) in which the standard is applicable.
1. The standard is accepted in a smaller geographic region or by a community that spans a small segment of the domain(s) in which the standard is applicable.

Conformance Specification

Conformance specification deals with how well the conformance requirements are defined (e.g., specification of levels of conformance, implementation options, test suites) and how well they are supported.

5. All seven of the following characteristics are true: test suites have been defined as part of the standard; the defined test suites account for permitted levels of conformance and for implementation options; executable test suites, conforming to those defined in the standard, exist; executable test suites demonstrating multi-vendor interoperability exist; testing organizations are available to execute available test suites; testing organizations are certified and independent of vendors and users; a reference implementation for the standard exists and is readily available.
4. Five or six of the seven characteristics listed above are true.
3. Three or four of the seven characteristics listed above are true.
2. One or two of the seven characteristics listed above are true.
1. None of the seven characteristics listed above are true.

4.1.3 Stability

Stability of Domain

Stability of domain measures the stability of the hardware and software technology in the domain of the standard, which will impact the stability of the standard itself. A stable domain implies that a standard will be meaningful for a longer period of time. More impact is attributed to a change in hardware technology than to one in software technology.

5. No technology in the domain appears to be changing.
4. Incidental software technology in the domain is changing.
3. Incidental hardware technology in the domain is changing.
2. Significant software technology in the domain is changing.
1. Significant hardware technology in the domain is changing

Lifecycle of Standard

This criterion gives some indication of where a standard is in its lifecycle. Is it still in draft form, or has it been accepted and approved? Is it still in its prime or is it starting to be displaced by competing standards?

In the case of a "standard" that is represented only by product(s), "approval" should be interpreted as acceptance by users (user base).

5. The standard has been approved. Its acceptance appears to be increasing or remaining steady.
4. The standard has been approved. Its acceptance appears to be declining at a slow rate, as competing standards start to appear in draft form.
3. The standard is in mature draft form and appears to be near approval. Its acceptance appears to be increasing.
2. The standard is in early draft form. Its acceptance is light.
1. The standard is obsolete or near obsolete. Its underlying technology is being replaced. Competing standards are mature.

Stability of Standard

The stability of a standard refers to the frequency with which it is being augmented or changed; when the expected next changes are to occur; the pattern of changes; and whether older versions of the standard have remained compatible with newer versions.

5. The standard is stable. No updates have occurred for over five years and none are currently planned.
4. The standard experiences predictable updates occurring with average frequency of once every five years or less. Updates represent additions to the standard rather than changes to existing functionality, so that products conforming to older versions of the standard will still conform to (a subset of) the newer version.
3. The standard experiences predictable updates occurring with average frequency of once every three years or less. Updates represent additions to the standard rather than changes to existing functionality, so that products conforming to older versions of the standard will still conform to (a subset of) the newer version.

2. The standard experiences predictable updates occurring with average frequency of once every year or less. Updates sometimes represent changes to the standard, so that products conforming to older versions of the standard do not conform to the newer version of the standard.

1. The standard is new enough that its stability cannot be determined or, the standard experiences unpredictable updates occurring at irregular intervals. Updates represent changes to the standard so that products conforming to older versions of the standard do not conform to the newer version of the standard.

4.1.4 Marketplace

Number of Acceptable Products

This criterion indicates the amount of choice available in selecting a COTS product to support the standard.

5. A large number (6 or more) of commercial products, spanning the range from minimal functionality to full functionality and from relatively low cost to higher cost, are available across different application platforms.

4. A moderate number (4 or more) of commercial products, spanning the range from minimal functionality to full functionality and from relatively low cost to higher cost, are available across different application platforms.

3. A moderate number (4 or more) of commercial products, offering similar levels of functionality at similar cost, are available.

2. A small number (2 or 3) of commercial products, offering similar levels of functionality at similar cost, are available.

1. Only one commercial product is available.

Marketplace Presence

Marketplace presence refers to the percentage of the marketplace covered by all products adhering to the standard, relative to the total market covered by all products of all competing standards.

5. The standard is the single marketplace leader. It has the highest market share and has no close competition.

4. The standard is in the marketplace-leading group of standards. It is one of a group of two or more standards that have similar market share. No standard has significantly higher market share.

3. The standard has significant market share, but at least one other standard has a more dominant market share.

2. The standard has a small but noticeable market share.

1. The standard has an insignificant market share position.

Cost of Standard

Cost of standard refers to the cost of complying with the standard as perceived by the user.

Factors that may be considered in evaluating cost include the inherent cost of any hardware or software technology espoused by the standard; cost of adapting the existing computing environment to the standard; and licensing restrictions if any.

5. The cost of adhering to the standard is much less (25% or more) than the cost of adhering to other standards with similar purpose.

4. The cost of adhering to the standard is less (5% or more) than the cost of adhering to other standards with similar purpose.

3. The cost of adhering to the standard is similar to the cost of adhering to other standards with similar purpose.

2. The cost of adhering to the standard is greater than (5% - 24%) the cost of adhering to other standards with similar purpose.

1. The cost of adhering to the standard is much greater than (25% or more) the cost of adhering to other standards with similar purpose.

4.2 GUIDELINES FOR USING THE STANDARDS EVALUATION MODEL

One way of using the standards evaluation model is to assess standards against all criteria in the model and to give all criteria equal importance in making the decision as to which standard should be chosen. This can be termed a "full evaluation". This section presents a few guidelines for tailoring and streamlining the use of the model, so that the evaluation process may be less strenuous than a full evaluation would be, and the results may be more relevant to a particular situation.

GUIDELINE 1: Use one or two significant criteria to narrow the set of standards under consideration.

Very often a single criterion such as marketplace acceptance is of such overriding importance that it can be used to eliminate candidates that don't measure up relative to it. It is possible that all but one standard can be eliminated using significant criteria, and the choice will be made without further evaluation.

GUIDELINE 2: Use only criteria that are important in a given context.

If certain criteria are not important in the context in which the standard will be used, they should be eliminated from the evaluation process. For example, if the domain is mature and only established standards are under consideration, the quality criteria can be eliminated in favor of the marketplace criteria. On the other hand, if the technology and standards in the domain are relatively new, marketplace criteria will not be able to discriminate among them, whereas quality criteria will.

GUIDELINE 3: The criteria that are used in the evaluation should be weighted to reflect their relative importance.

If certain aspects of a standard are more important because of the context in which the standard will be used, the standards evaluation criteria can be weighted to reflect that importance.

The non-functional and external requirements are important indicators of which standards evaluation criteria will be most important. With many non-functional requirements, the evaluation criteria most relevant to achieving them are obvious. For example, if cost-related requirements are important, then the cost criterion will be particularly significant.

For non-functional requirements relating to portability, scalability, and interoperability, several standards evaluation criteria may be significant in achieving the requirements, as documented in Table 4-1.

Table 4-1. Evaluation Criteria for Portability, Scalability, Interoperability

Non-functional Requirement Area	Significant Evaluation Criteria
Portability	Completeness Unambiguous Expression Strictly-defined Interface Marketplace Presence Stability
Scalability	Flexibility (e.g., 16 vs. 32-bit format) Performance (of acceptable products)
Interoperability	Completeness Unambiguous Expression Strictly-defined Interface Flexibility (e.g., protocol flexibility) Scope of Acceptance Marketplace Presence

Other factors to consider when weighting evaluation criteria include the scope or impact of the system being developed. This is often addressed in the external requirements. For example, if the new system is to have an enterprise-wide impact, it will probably be longer-lived than a local system would be. Certain factors such as the stability of the standard, support for the standard, and flexibility of the standard in adapting to future developments become relatively more important.

4.3 STANDARDS EVALUATION MODEL EXAMPLE

The following hypothetical situation is presented to illustrate the use of the standards evaluation model. A contractor organization has just been awarded a contract for a large defense information system, which is to incorporate portions of several legacy systems as well as a significant amount of new software development. The decision has already been made to use object-oriented technology for the new development. The technical and managerial staff have experience in both Ada and C++, but in order to conform to the DoD mandate have a preference for using Ada 95. The organization has decided to use the standards evaluation model

to assess Ada 95 relative to the qualities they believe they will need from the programming language chosen for the project.

Their first step is to identify the standards evaluation criteria that are most important and relevant to their situation. The organization decides to use the criteria of completeness, unambiguous expression, strictly-defined interface, conformance specification, stability of standard, number of acceptable products, and marketplace presence. This will support their goals to have software that is portable across several operating systems and hardware platforms, to have a variety of tools to choose from that have been ascertained to conform to the language specification, and to have stability in their software and tool set.

They analyze their needs and come up with the following desired levels of assessment for the seven evaluation criteria areas as shown in Table 4-2.

Table 4-2. Hypothetical Desired Levels of Assessment

	Completeness	Unamb Express	Strict Interface	Conformance	Stability	# of Accept Prods	Market Presence
Organizational Needs	5	4	5	4	3	4	3

A technical person who has in-depth knowledge of the Ada 95 standard is assigned the task of evaluating the standard relative to the seven chosen evaluation criteria, using the assessment guidelines. The reasoning for several of the resulting assessment scores is described below and in Table 4-3.

- Strictly-defined interface: Most aspects of the language are strictly defined in the standard. The few exceptions are typical of other programming languages. For example, a minimum size is given for Integers (16 bits) but no maximum is specified. This criterion is assessed at level 4. The Ada 95 standard includes several Annexes which are optional to implementers, but this represents optional functions or features rather than options in the interface of a given feature. Hence it does not lower the assessment level.

- Stability of Standard: The last update to Ada was in 1983, and no update to Ada 95 is currently planned. Hence this criterion is assessed at level 5. There could be some question as to whether Ada 95 is the same language (standard) as Ada, but it is officially considered an update to the Ada standard.

- Marketplace Presence: This criterion is assessed at level 2. Other de jure and de facto standards such as C, C++, COBOL, and Fortran have significantly larger market share. While Ada is stronger in safety-critical, aerospace, and military weapon system domains, its overall presence rates a 2.

The scores for all seven evaluation criteria are compared against the organizational needs (see Table 4-3). Two potential risk areas are identified, related to the criteria of strictly-defined interface and marketplace presence.

Table 4-3. Hypothetical Assessment Results

	Completeness	Unamb Express	Strict Interface	Conformance	Stability	# of Accept Prods	Market Presence
Organizational Needs	5	4	5	4	3	4	3
Ada 95	5	5	4	5	5	4	2
Potential Risk			*				*

The organization at this point must assess the potential risk attributable to the lower-than-desired assessment scores. As a result of that assessment, they might decide to finalize their decision to use Ada 95. At that point, they could make use of the product evaluation model to assess several Ada 95 compilers and development support tools. Alternatively, they might decide to use the standards evaluation model to assess C++ as a candidate programming language, look at its potential risks to the organization, and compare its assessed values to those of Ada 95. This will give them more information to use in making a final decision on which of the two languages will best suit their needs.

5. SUMMARY

The standards evaluation model and the standards-based COTS products evaluation model have identical forms. Each provides a set of evaluation criteria grouped in broad categories. In addition, the standards evaluation model includes guidelines for assessing a standard relative to each of the evaluation criteria in the model. The models can serve as checklists, ensuring that important considerations are not overlooked when selecting a standard or product. The use of the models can help provide consistency among standard and product evaluations.

The models were developed to help users select from among competing standards or products. They can also be used to evaluate a single standard or product against organizational requirements for the standard or product.

The models are flexible and can be tailored to a given situation. Certain criteria can be emphasized or de-emphasized, according to situational needs. Further, the models themselves can easily be extended or modified based on experience in their use. Criteria can be added or deleted, and assessment guidelines further developed. As the models are more widely used, they can evolve to become more precise instruments for evaluating standards and products.

APPENDIX A. REFERENCES

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13. ABSTRACT (Maximum 200 words)

This paper describes two models, one for evaluating standards and the other for evaluating standards-based, commercial off-the-shelf (COTS) products. Their intended use is as an aid in making a selection among competing standards or standards-based COTS products, based on which can best serve the identified needs of a particular organization. The models were formulated based on interviews of professionals experienced in standards development. Each model consists of a set of evaluation criteria that were judged to be important determinants of successful standards and products. The standards evaluation model was further developed to contain assessment guidelines for each of its evaluation criteria. The models do not replace testing or other hands-on methods of evaluation, but rather use the results of such efforts to evaluate some of their criteria. A preliminary use of the standards evaluation model suggests that it can be a helpful tool, given that its limitations and its place within a total decision-making process are understood.

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